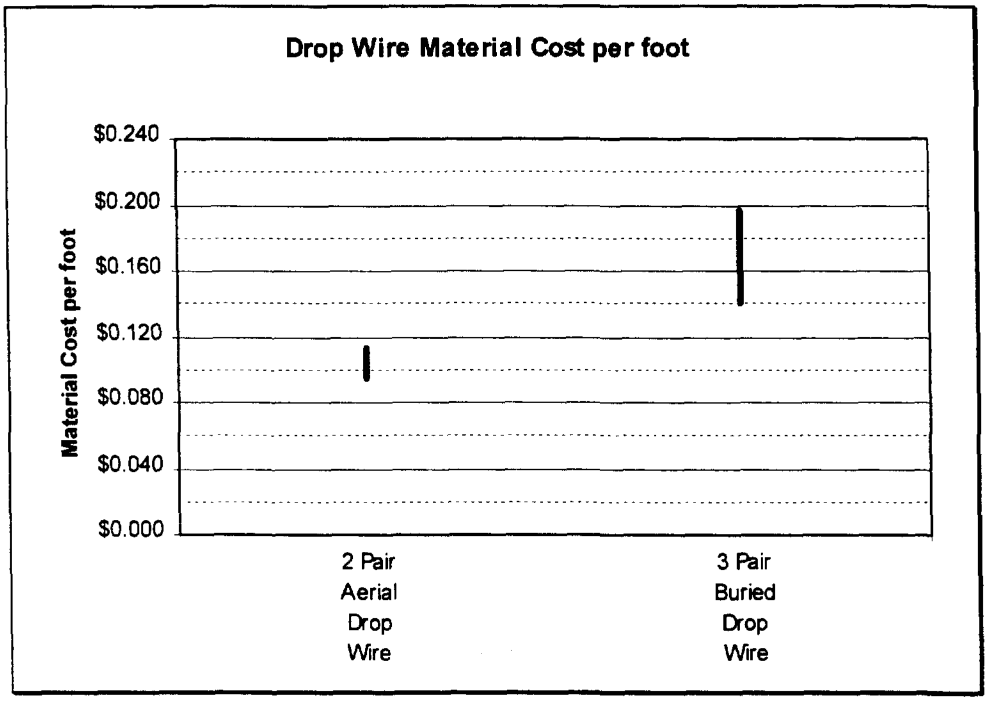
Default Values:

Drop Cable Investment, per foot		
	Material Cost Per foot	Pairs
Aerial	$0.095	2
Buried	$0.140	3

Support: Price quotes for material were received from several sources. Results were as follows:



2.3 CABLE AND RISER INVESTMENT

2.3.1. Distribution Cable Sizes

Definition: Distribution plant connects feeder plant, normally terminated at a Serving Area Interface (SAI), to the customer's block terminal. "Distribution network design requires more distribution pairs than feeder pairs, so distribution cables are more numerous, but smaller in cross section, than feeder cables."[3] The Hatfield Model default values represent the array of distribution cable sizes assumed to be available for placement in the network.

Default Values:

Cable Sizes
2400
1800
1200
900
600
400
200
100
50
25
12
6

Support: These are cable sizes typically available to, and used by, telephone companies. Although three additional sizes of distribution cable (2100 pair, 1500 pair, and 300 pair cable) can be used, the industry has largely abandoned use of those sizes in favor of reduced, simplified inventory.

2.3.2. Distribution Cable, Cost per Foot

Definition: The cost per foot of copper distribution cable, as a function of cable size, including the costs of engineering, installation, and delivery, as well as the cable material itself.

[3] Bellcore, *Telecommunications Transmission Engineering*, 1990, p. 91.

Default Values:

Copper Distribution Cable, $/foot	
Cable Size	Cost/foot (including engineering, installation, delivery and material)
2400	$20.00
1800	$16.00
1200	$12.00
900	$10.00
600	$7.75
400	$6.00
200	$4.25
100	$2.50
50	$1.63
25	$1.19
12	$0.76
6	$0.63

Support: These costs reflect the use of 24-gauge copper distribution cable for cable sizes below 400 pairs, and 26-gauge copper distribution cable for cable sizes of 400 pairs and larger. Although 24-gauge copper is not required for transmission requirements within 18,000 feet of a digital central office with a 1,500 ohm limit, or a GR-303 integrated digital loop carrier system with a 1,500 ohm limit, a heavier gauge of copper is used in smaller cable sizes to prevent damage from craft handling wires in distribution terminals and pedestals. For cables of 400 pairs and larger, splices are normally enclosed in splice cases, and are not subject to wire handling problems.

Cable below 400 Pairs: Outside plant planning engineers commonly assume that the cost of cable material can be represented as an a + bx straight line graph. In fact, Bellcore Planning tools, EFRAP I, EFRAP II, and LEIS:PLAN have the engineer develop such an a + bx equation to represent the cost of cable. As technology, manufacturing methods, and competition have advanced, the price of cable has been reduced. While in the past, the cost of copper cable was typically ($.50 + $.01 per pair) per foot, current costs are typically ($.30 + $.007 per pair) per foot.

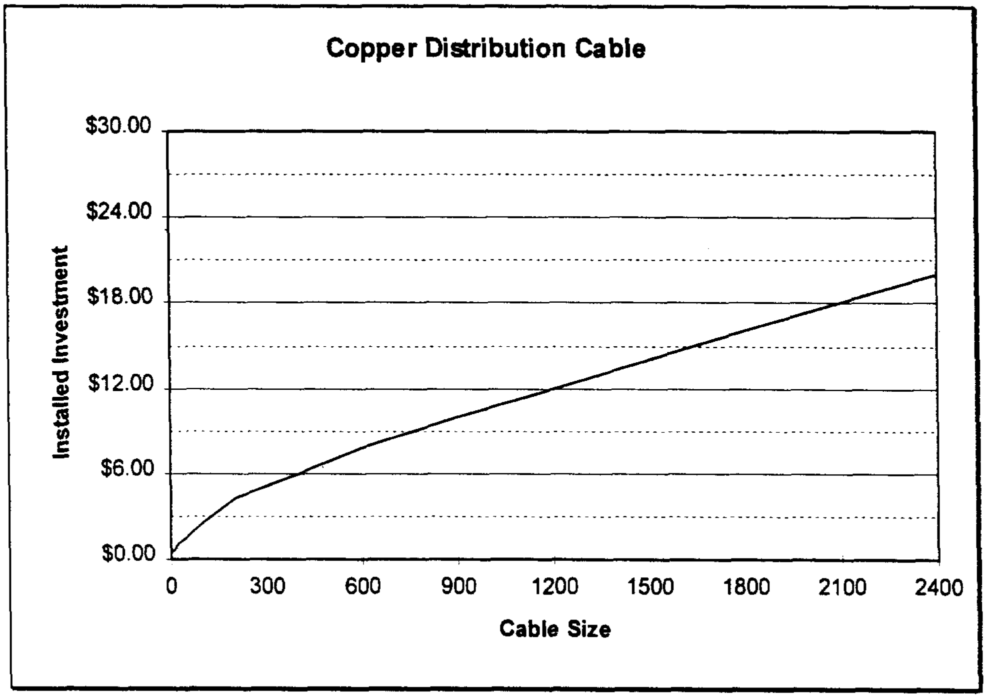
In the opinion of expert outside plant engineers, material represents approximately 40% of the total installed cost. This is a widely used rule of thumb among outside plant engineers. Experience of outside plant experts used for developing the HM 3.1 includes writing and administering hundreds of outside plant "estimate cases" (large undertakings). Outside plant engineering experts have agreed that 40% material to total installed cost is a good approximation. Such expert opinions were also used to determine that the average engineering content for installed copper cable is 15% of the installed cost. The remaining 45% represents direct labor for placing and splicing cable, exclusive of the cost of splicing block terminals into the cable.[4]

Cable of 400 Pairs and Larger: As copper cable sizes become larger, engineering cost is based more and more on sheath feet, rather than cable size. The same is true for cable placing and splice set-up. Therefore

[4] The formula would produce a material price of $.38/ft. for 12 pair 24 gauge cable, and $.34/ft. for 6 pair 24 gauge cable. An actual quote for materials was obtained at $.18/ft. for 12 pair 24 gauge cable, and $.12/ft. for 6 pair 24 gauge cable. The significant difference in material cost is perceived to be the result of the very small quantity of sheath required for 12 and 6 pair cables. Therefore, the formula generated material price was reduced by $.20 and $.22 for 12 and 6 pair cables respectively, but the engineering and labor components were retained at original formula levels, since neither would be affected by the reduction in material price.

the linear relationship between the number of copper pairs and installed cost is somewhat reduced. A review of many installed cable costs around the country were used by the engineering team to estimate the installed cost of copper cable for sizes of 400 pairs and larger.

The following chart represents the values used in the model.



2.3.3. Riser Cable Size and Cost per Foot

Definition: The cost per foot of copper riser cable (cable inside high-rise buildings), as a function of cable size, including the costs of engineering, installation, and delivery, as well as the cable material itself.

Default Values:

Riser Cable, $/foot	
Cable Size	Cost/foot (including engineering, installation, delivery and material)
2400	$20.00
1800	$16.00
1200	$12.00
900	$10.00
600	$7.75
400	$6.00
200	$4.25
100	$2.50
50	$1.63
25	$1.19
12	$0.76
6	$0.63

Support: Riser cable is assumed to cost the same per foot as equivalent-sized distribution cable.

2.4. POLES AND CONDUIT

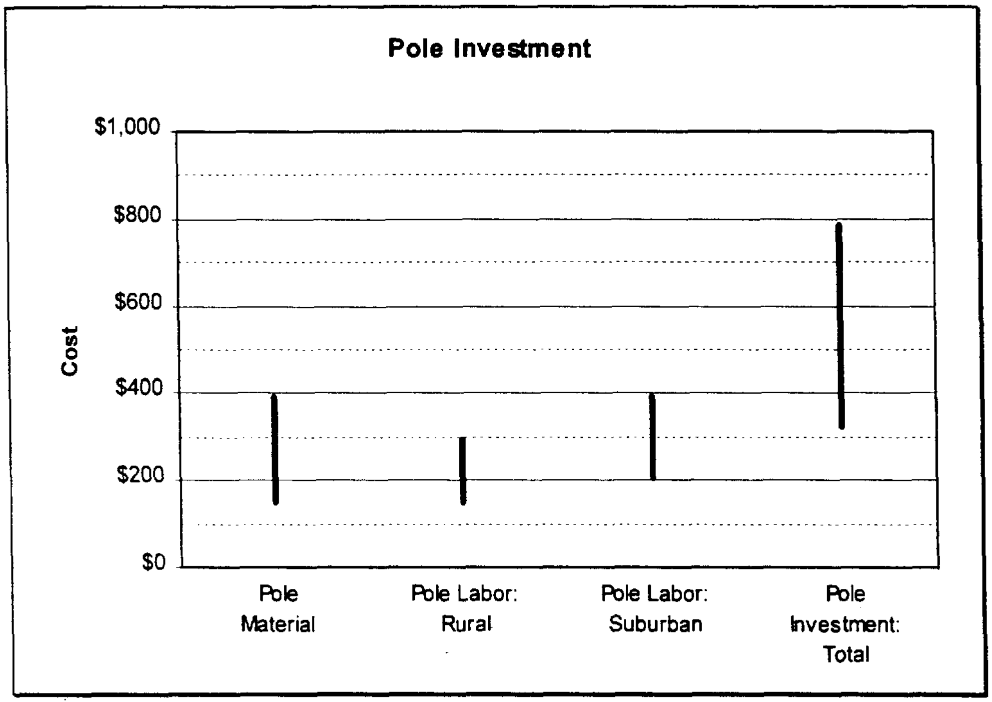
2.4.1. Pole Investment

Definition: The installed cost of a 40 foot Class 4 treated southern pine utility pole.

Default Values:

Pole Investment	
Materials	$201
Labor	$216
Total	*$417*

Support: Pole investment is a function of the material and labor costs of placing a pole. Costs include periodic down-guys and anchors. Utility poles can be purchased and installed by employees of ILECs, but are frequently placed by contractors. Several sources revealed the following information on prices.



The exempt material load on direct labor includes ancillary material not considered by FCC Part 32 as a unit of plant. That includes items such as downguys and anchors that are already included in the pole placement labor cost. The steel strand run between poles is likewise an exempt material item, charged to the aerial cable account. The cost of steel strands is not included in the cost of poles; it is included in the installed cost of aerial cable.

2.4.2. Buried Copper Cable Sheath Multiplier (feeder and distribution)

Definition: The additional cost of the filling compound used in buried cable to protect the cable from moisture, expressed as a multiplier of the cost of non-filled cable.

Default Value:

Buried Copper Cable Sheath Multiplier	
Multiplier	1.04

Support: Filled cable is designed to minimize moisture penetration in buried plant. This factor accounts for the extra material cost incurred by using a more expensive type of cable designed specifically for buried application.

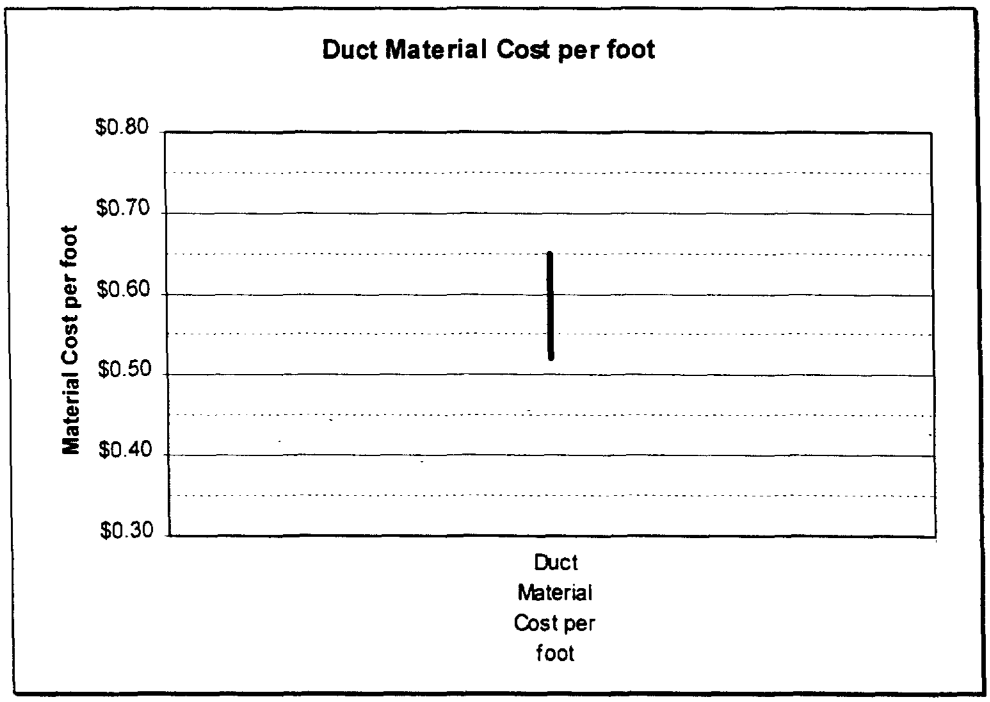
2.4.3. Conduit Material Investment per Foot

Definition: Material cost per foot of 4" PVC pipe.

Default Values:

Material cost per foot of duct for 4" PVC	
4" PVC	$0.60

Support: Several suppliers were contacted for material prices. Results are shown below.



The labor to place conduit in trenches is included in the cost of the trench, not in the conduit cost.

Under the Model's assumptions, a relatively few copper cables serving short distances (e.g., less than 9,000 ft. feeder cable length), and one or more fiber cables to serve longer distances, will be needed. Since the number of cables in each of the four feeder routes is relatively small, the predominant cost is that of the trench, plus the material cost of a few additional 4" PVC conduit pipes. No additional allowance is necessary for stabilizing the conduit in the trench.

2.4.4. Spare Tubes per Route

Definition: The number of spare tubes (i.e., conduit) placed per route.

Default Value:

Spare Tubes per Route	
# Spare Tubes	1

Support: "A major advantage of using conduits is the ability to reuse cable spaces without costly excavation by removing smaller, older cables and replacing them with larger cables or fiber facilities. Some companies reserve vacant ducts for maintenance purposes."[5] Version 4.0 of the Hatfield Model provides one spare maintenance duct (as a default) in each conduit run.

2.4.5. Regional Labor Adjustment Factor

Definition: A factor that adjusts the labor cost portion of certain investments to account for regional differences in the availability of trained labor, union contracts, and cost of living factors.

Default Value:

Regional Labor Adjustment Factor	
Factor	1.0

Support: Different areas of the country are known to experience variations in wages paid to technicians, depending on availability of trained labor, union contracts, and cost of living factors. The adjustment applies only to that portion of installed costs pertaining to salaries. It does not apply to loading factors such as exempt material, construction machinery, motor vehicles, leases and rentals of special tools and work equipment, welfare, pension, unemployment insurance, workers compensation insurance, liability insurance, general contractor overheads, subcontractor overheads, and taxable and non-taxable fringe benefits.

The regional adjustment factor is applied to the model as follows. For heavy construction of outside plant cable, the model assumes a fully loaded direct labor cost of $55.00 per hour for a placing or splicing technician who receives pay of $20 per hour. For copper feeder and copper distribution cable, the Hatfield Model assumes that this fully loaded direct labor component accounts for 45% of the investment.

Because $20 is 36.4% of the fully loaded $55 per hour figure, the effect of the Regional Labor Adjustment Factor is .364 x .45, or 16.4% of the installed cost of copper cable. Therefore, the labor adjustment factor is applied to 16.4% of the installed cost of copper cable.

The labor adjustment factor also applies to pole labor, NID installation, conduit and buried placement, and drop installation. In the feeder plant, the factor applies to manhole and pullbox installation as well as to cable and other structure components.

Contract labor is used for buried trenching, conduit trenching, and manhole/pullbox excavation. Contract labor (vs. equipment + other charges) is 25% of total contractor cost. Direct salaries are 50% of the "labor & benefits" cost. The fraction of investment that represents labor cost for these items, and is, therefore,

[5] *BOC Notes on the LEC Networks - 1994*, Bellcore, p. 12-42.

subject to the regional labor adjustment factor, is 0.25 times 0.50, or 0.125 of the trenching and excavation costs.

Once the adjustment factors are determined in this fashion, the factor is multiplied by the corresponding unit cost to determine the amount of investment affected by the adjustment. This amount is then multiplied by the specific regional labor adjustment factor to determine the modified investment. For instance, if buried installation trenching per foot is normally $1.77, the adjustment factor of 0.125 applied to this amount is $.2213. If the regional adjustment was 1.07 (e.g., California), the increased installation cost is .07 times $.2213, or $.015.

Application of Regional Labor Adjustment Factor on Buried Installation			
Density Zone	Buried Installation per Foot	Labor Content Affected	Investment Affected per Foot
0-5	$1.77	0.125	$0.2213
5-100	$1.77	0.125	$0.2213
100-200	$1.77	0.125	$0.2213
200-650	$1.93	0.125	$0.2413
650-850	$2.17	0.125	$0.2713
850-2,550	$3.54	0.125	$0.4425
2,550-5,000	$4.27	0.125	$0.5338
5,000-10,000	$13.00	0.125	$1.6250
10,000+	$45.00	0.125	$5.6250

Application of Regional Labor Adjustment Factor on Conduit Installation			
Density Zone	Conduit Installation per Foot	Labor Content Affected	Investment Affected per Foot
0-5	$10.29	0.125	$1.2863
5-100	$10.29	0.125	$1.2863
100-200	$10.29	0.125	$1.2863
200-650	$11.35	0.125	$1.4188
650-850	$11.38	0.125	$1.4225
850-2,550	$16.40	0.125	$2.0500
2,550-5,000	$21.60	0.125	$2.7000
5,000-10,000	$50.10	0.125	$6.2625
10,000+	$75.00	0.125	$9.3750

Application of Regional Labor Adjustment Factor on Manhole Installation			
Density Zone	Manhole Excavation & Backfill	Labor Content Affected	Investment Affected per Manhole
0-5	$2,800	0.125	$350
5-100	$2,800	0.125	$350
100-200	$2,800	0.125	$350
200-650	$2,800	0.125	$350
650-850	$3,200	0.125	$400
850-2,550	$3,500	0.125	$438
2,550-5,000	$3,500	0.125	$438
5,000-10,000	$5,000	0.125	$625
10,000+	$5,000	0.125	$625

Application of Regional Labor Adjustment Factor on Fiber Pullbox Installation			
Density Zone	Pullbox Excavation & Backfill	Labor Content Affected	Investment Affected per Pullbox
0-5	$220	0.125	$27.50
5-100	$220	0.125	$27.50
100-200	$220	0.125	$27.50
200-650	$220	0.125	$27.50
650-850	$220	0.125	$27.50
850-2,550	$220	0.125	$27.50
2,550-5,000	$220	0.125	$27.50
5,000-10,000	$220	0.125	$27.50
10,000+	$220	0.125	$27.50

Application of Regional Labor Adjustment Factor on Copper Distribution Cable Installation			
Copper Distribution Cable Size	Installed Copper Distribution Cost	Labor Content Affected	Investment Affected per Foot
2,400	$20.00	0.164	$3.28
1,800	$16.00	0.164	$2.62
1,200	$12.00	0.164	$1.97
900	$10.00	0.164	$1.64
600	$7.75	0.164	$1.27
400	$6.00	0.164	$0.98
200	$4.25	0.164	$0.70
100	$2.50	0.164	$0.41
50	$1.63	0.164	$0.27
25	$1.19	0.164	$0.20
12	$.76	0.201	$0.15
6	$.63	0.219	$0.14

Application of Regional Labor Adjustment Factor on Copper Feeder Cable Installation			
Copper Feeder Cable Size	Installed Copper Feeder Cost	Labor Content Affected	Investment Affected per Foot
4,200	$29.00	0.164	$4.76
3,600	$26.00	0.164	$4.26
3,000	$23.00	0.164	$3.77
2,400	$20.00	0.164	$3.28
1,800	$16.00	0.164	$2.62
1,200	$12.00	0.164	$1.97
900	$10.00	0.164	$1.64
600	$7.75	0.164	$1.27
400	$6.00	0.164	$0.98
200	$4.25	0.164	$0.70
100	$2.50	0.164	$0.41

Application of Regional Labor Adjustment Factor on Fiber Feeder Cable Installation				
Fiber Feeder Cable Size	Installed Fiber Feeder Cost	Labor Content Affected	Factor	Investment Affected per Foot
216	$13.10	$2.00	0.364	$0.73
144	$9.50	$2.00	0.364	$0.73
96	$7.10	$2.00	0.364	$0.73
72	$5.90	$2.00	0.364	$0.73
60	$5.30	$2.00	0.364	$0.73
48	$4.70	$2.00	0.364	$0.73
36	$4.10	$2.00	0.364	$0.73
24	$3.50	$2.00	0.364	$0.73
18	$3.20	$2.00	0.364	$0.73
12	$2.90	$2.00	0.364	$0.73

Application of Regional Labor Adjustment Factor on Outdoor SAI Installation			
Outdoor SAI Total Pairs Terminated	Installed Outdoor SAI	Labor Content Affected	Investment Affected per Outdoor SAI
7,200	$4,469	0.164	$733
5,400	$3,569	0.164	$585
3,600	$2,610	0.164	$428
2,700	$2,028	0.164	$333
1,800	$1,500	0.164	$246
1,200	$1,071	0.164	$176
900	$902	0.164	$148
600	$642	0.164	$105
300	$300	0.164	$49
150	$250	0.164	$41
50	$250	0.164	$41

Application of Regional Labor Adjustment Factor on Indoor SAI Installation			
Indoor SAI Distribution Cable Size	Installed Indoor SAI	Labor Content Affected	Investment Affected per Indoor SAI
7,200	$1,052	0.164	$733
5,400	$864	0.164	$585
3,600	$576	0.164	$428
2,700	$432	0.164	$333
1,800	$288	0.164	$246
1,200	$192	0.164	$176
900	$96	0.164	$148
600	$48	0.164	$105
300	$48	0.164	$49
150	$48	0.164	$.41
50	$48	0.201	$41

Telco Installation & Repair labor (Drop & NID installation): Regional Labor Adjustment Factor applies to $20 of the $35 loaded labor rate (exclusive of exempt material loadings).

Application of Regional Labor Adjustment Factor on NID Installation			
Type of NID	NID Basic Labor	Labor Content Affected	Investment Affected per NID
Residence	$15.00	0.571	$8.57
Business	$15.00	0.571	$8.57

Application of Regional Labor Adjustment Factor on Aerial Drop Installation			
Density Zone	Installed Aerial Drop	Labor Content Affected	Investment Affected per Drop
0-5	$23.33	0.571	$13.33
5-100	$23.33	0.571	$13.33
100-200	$17.50	0.571	$10.00
200-650	$17.50	0.571	$10.00
650-850	$11.67	0.571	$6.67
850-2,550	$11.67	0.571	$6.67
2,550-5,000	$11.67	0.571	$6.67
5,000-10,000	$11.67	0.571	$6.67
10,000+	$11.67	0.571	$6.67

Application of Regional Labor Adjustment Factor on Buried Drop Installation			
Density Zone	Installed Buried Drop per Foot	Labor Content Affected	Investment Affected per Drop
0-5	$0.75	0.125	$0.094
5-100	$0.75	0.125	$0.094
100-200	$0.75	0.125	$0.094
200-650	$0.75	0.125	$0.094
650-850	$0.75	0.125	$0.094
850-2,550	$0.75	0.125	$0.094
2,550-5,000	$1.13	0.125	$0.141
5,000-10,000	$1.50	0.125	$0.188
10,000+	$5.00	0.125	$0.625

The following chart shows recommended default values for each state.

Regional Labor Adjustment Factor:

Direct Labor costs vary among regions in the United States. A variety of sources can be used for labor adjustment factors.[6] The following statewide labor adjustment factor indexes can be used as default values:

[6] See, for example, Square Foot Costs, 18th Annual Edition, R.S. Means Company, Inc., 1996, p.429-433.

State	Factor[7]
Alaska	1.25
Hawaii	1.22
Massachusetts	1.09
California	1.07
Michigan	1.01
New York	1.00
New Jersey	1.00
Rhode Island	1.00
Illinois	1.00
Minnesota	0.99
Connecticut	0.98
Pennsylvania	0.97
Nevada	0.95
Washington (State)	0.92
Oregon	0.92
Delaware	0.92
Indiana	0.92
Missouri	0.90
Maryland	0.89
New Hampshire	0.86
Montana	0.85
West Virginia	0.84
Ohio	0.83
Wisconsin	0.83
Arizona.	0.81
Colorado	0.77
New Mexico	0.76
Vermont	0.75
Iowa	0.74
North Dakota	0.74
Idaho	0.73
Maine	0.73
Kentucky	0.73
Louisiana	0.72
Kansas	0.71
Utah	0.71
Tennessee	0.70
Oklahoma	0.69
Florida	0.68
Virginia	0.67
Nebraska	0.65
Texas	0.65
South Dakota	0.64
Georgia	0.62

[7] Martin D. Kiley and Marques Allyn, eds., *1997 National Construction Estimator 45th Edition*, pp. 12-15. [Normalized for New York State as 1.00]

State	Factor[7]
Arkansas	0.61
Wyoming	0.60
Alabama	0.58
Mississippi	0.58
South Carolina	0.55
North Carolina	0.51

2.5. BURIED, AERIAL, AND UNDERGROUND PLACEMENT FRACTION

Definition: Outside plant structure refers to the set of facilities that support, house, guide, or otherwise protect distribution and feeder cable. There are three types of structure: aerial, buried, and underground.

a) Aerial Structure

Aerial structure includes poles and associated hardware.[8] Pole investment is a function of the material and labor costs of placing a pole. A user-adjustable input adjusts the labor component of poles investment to local conditions. The Hatfield Model computes the total investment in aerial distribution and feeder structure within a CBG by evaluating relevant parameters, including the distance between poles, the investment in the pole itself, the total cable sheath mileage, and the fraction of aerial structure along the route.

Poles are assumed to be 40 foot Class 4 poles. The spacing between poles for aerial cable is fixed within a given density range, but may vary between density ranges.

b) Buried Structure

Buried structure consists of trenches. The additional cost for protective sheathing and waterproof filling of buried cable is a fixed amount per foot in the case of fiber cable, and is a multiplier of cable cost in the case of copper cable.[9] The total investment in buried structure is a function of total route mileage, the fraction of buried structure, investment in protective sheathing and filling and the density-range-specific cost of trenching.

c) Underground Structure

Underground structure consists of conduit and, for feeder plant, manholes and pullboxes. Manholes are used in conjunction with copper cable routes; pullboxes are used with fiber cable. The total investment in a manhole varies by density zone, and is a function of the following investments: materials, frame and cover, excavation, backfill, and site delivery. Investment in fiber pullboxes is a function of materials and labor. Underground cables are housed in conduit facilities that extend between manholes or pullboxes. The total investment in underground structure is a function of total route mileage, the fraction of underground structure, investment in conduit manholes, and pullboxes, and the cost of trenching needed to hold the conduit.

In each line density range, there may be a mixture of aerial, buried, and underground structure. For example, in downtown urban areas it is frequently necessary to install cable in underground conduit systems, while rural areas may consist almost exclusively of aerial or direct-buried plant.

Users can adjust the mix of aerial, underground and buried cable assumed within the Hatfield model. These settings may be made separately by density zone for fiber feeder, copper feeder, and copper distribution cables.

---

[8] In the two highest density zones, aerial structure is also assumed to consist of intrabuilding riser cable and "block cable" attached to buildings. In HM 4.0, this "aerial" structure does not include poles.

[9] The default values for sheathing are an additive $.20 per foot for fiber and a multiplier of 1.04 for copper. The different treatment reflects the fact that the outside dimension of fiber cable is essentially constant for different strand numbers, while the dimension of copper cable increases with the number of pairs it contains.

Default Values:

Distribution Cable Structure Fractions			
Density Zone	Aerial/Block Cable	Buried Cable	Underground Cable (calculated)
0-5	.25	.75	*0*
5-100	.25	.75	*0*
100-200	.25	.75	*0*
200-650	.30	.70	*0*
650-850	.30	.70	*0*
850-2,550	.30	.70	*0*
2,550-5,000	.30	.65	*.05*
5,000-10,000	.60	.35	*.05*
10,000+	.85	.05	*.10*

Support: It is the opinion of outside plant engineering experts that density, measured in Access Lines per Square Mile, is a good determinant of structure type. That judgment is based on the fact that increasing density drives more placement in developed areas, and that as developed areas become more dense, placements will more likely occur under pavement conditions.

Aerial/Block Cable:

"The most common cable structure is still the pole line. Buried cable is now used wherever feasible, but pole lines remain an important structure in today's environment."[10]

Where an existing pole line is available, cable is normally placed on the existing poles. Abandoning an existing pole line in favor of buried plant is not usually done unless such buried plant provides a much less costly alternative.

HM 4.0 accounts for drop wire separately. Cable attached to the [out]sides of buildings, normally found in higher density areas, are also appropriately classified to the aerial cable account. To facilitate modeling, HM 4.0 reasonably includes Intrabuilding Network Cable under its treatment of aerial cable.

Therefore, the default percentages above 2,550 lines per square mile indicate a growing amount of block and intrabuilding cable, rather than cable placed on pole lines (although existing joint use pole lines are also more prevalent in older, more dense neighborhoods built prior to 1980).

Buried Cable:

Default values in HM 4.0 reflect an increasing trend toward use of buried cable in new subdivisions. Since 1980, new subdivisions have usually been served with buried cable for several reasons. First, before 1980, cables filled with water blocking compounds had not been perfected. Thus, prior to that time, buried cable was relatively expensive and unreliable. Second, reliable splice closures of the type required for buried facilities were not the norm. And third, the public now clearly desires more out-of-sight plant for both aesthetic and safety-related reasons. Contacts with telephone outside plant engineers, architects and property developers in several states confirm that in new subdivisions, builders typically not only prefer buried plant that is capable of accommodating multiple uses, but they usually dig the trenches at their own expense and place power, telephone, and CATV cables in the trenches, if the utilities are willing to supply the materials. Thus, many buried structures are available to the LEC at no charge, although the Model does not reflect such savings, since it is uncertain.

[10] *BOC Notes on the LEC Networks - 1994*, Bellcore, p. 12-41.

Underground Cable:

Underground cable, conduit, and manholes are primarily used for feeder and interoffice transport cables, not for distribution cable. Distribution plant in congested, extensively paved, high density areas usually runs only a short distance underground from the SAI to the block terminal, thus it requires no intermediate splicing chambers. In high density residential, distribution cables are frequently run from pole lines, under a street and back up onto a pole line, or from buried plant, under a street and back to a buried cable run. Such conduit runs are short enough to not require a splicing chamber or manhole and are therefore classified to the aerial or buried cable account, respectively.

There may be rare exceptions where distribution cable from a SAI is so long that it requires an underground splicing chamber (manhole). Sometimes feeder cable will be extended, via a lateral, into a SAI, and distribution pairs in the same feeder stub will run back into the same manhole for further routing to aerial or buried structures down a street. In those cases, manholes and conduit were placed for feeder cable and have already been accounted for in the cost of feeder plant structure. Therefore it is unnecessary to double count such manholes and conduit when used occasionally for the routing of a distribution backbone cable.

In a "campus environment," where underground structure is used, it is owned and operated by the owner of the campus and not the ILEC. The cable is treated as Intrabuilding Network Cable between buildings on one customer's premises, and the cost of such cable is not included in the model.

2.6. CABLE FILL AND POLE SPACING

2.6.1. Distribution Cable Fill Factors

Definition: The Hatfield Model uses the distribution cable fill factor input to calculate the size of cable needed to serve a given quantity of demand. HM 4.0 divides the number of pairs required in a distribution cable by this factor to determine the minimum number of pairs required, then uses the next larger available size cable.

Default Values:

Distribution Cable Fill Factors	
Density Zone	Fill Factors
0-5	.50
5-100	.55
100-200	.55
200-650	.60
650-850	.65
850-2,550	.70
2,550-5,000	.75
5,000-10,000	.75
10,000+	.75

Support: In determining appropriate cable size, an outside plant engineer is more interested in a sufficient number of administrative spares than in the percent fill ratio. The appropriate "target" distribution cable fill factor, therefore, will vary depending upon the size of cable. For example, 75% fill in a 2400 pair cable provides 600 spares. However, 50% spare in a 6 pair cable provides only 3 spares. Since smaller cables are used in lower density zones, Distribution Cable Fill Factors in HM 4.0 are lower in the lowest density zones to account for this effect.

In general, the level of spare capacity provided by default values in HM 4.0 is sufficient to meet current demand plus some amount of growth. Because the model calculates the unit loop investment cost as the total loop investment (including spare capacity), divided by the current loop demand, the resulting unit costs are a conservatively high estimate of the economic cost of meeting current loop demand. This occurs because, in reality, some of the spare distribution plant can and will be used to satisfy additional loop demand in the future, without causing any additional investment cost, thus a larger number of customers will pay for the cable over time. In this sense, the HM 4.0 default values for the distribution cable fill factors are conservatively low from an economic costing standpoint.

2.6.2. Distribution Pole Spacing

Definition: Spacing between poles supporting aerial distribution cable.

Default Values:

Distribution Pole Spacing	
Density Zone	Spacing
0-5	250
5-100	250
100-200	200
200-650	200
650-850	175
850-2,550	175
2,550-5,000	150
5,000-10,000	150
10,000+	150

Support: Distances between poles are longer in more rural areas for a several reasons. Poles are usually placed on property boundaries, and at each side of road intersections (unless cable is run below the road surface in conduit). Property boundaries tend to be farther apart in less dense areas, and road intersections are also farther apart.

Depending on the weight of the cable, and the generally accepted guideline that sag should not exceed 10 feet at mid-span, while still maintaining appropriate clearances as designated by the National Electric Safety Code, very long spans between poles may be achieved. This length may be as great as 1,500 feet using heavy gauge strand and very light cable, or may be shorter for heavier cables.[11] In practice, much shorter span distances are employed, usually 400 feet or less.

"...where conditions permit, open wire spans can approach 400 feet in length with practical assurance that the lines will withstand any combination of weather condition. Longer spans mean savings in construction costs and a net reduction in over-all plant investment, including fewer poles to buy, smaller quantity of pole hardware required, and less construction time. The use of long spans also means a reduction in maintenance expense."[12]

[11] Bellcore, *Clearance for Aerial Cable and Guys in Light, Medium and Heavy Loading Areas, (BR 627-070-015), Issue 1*, 1987.
see also, Bellcore, *Clearances for Aerial Plant, (BR 918-117-090), Issue 5*, 1987.
see also, Bellcore, *Long Span Construction (BR 627-370-XXX)*, date unk.

[12] Lee, Frank E., *Outside Plant, abc of the Telephone Series, Volume 4*, abc TeleTraining, Inc., Geneva, IL, 1987, p. 41.

2.7. GEOLOGY AND POPULATION CLUSTERS

2.7.1. Distribution Distance Multiplier, Difficult Terrain

Definition: The amount of extra distance required to route distribution and feeder cable around difficult soil conditions, expressed as a multiplier of the distance calculated for normal situations.

Default Value:

Distribution Distance Multiplier, Difficult Terrain
1.0

Support: HM 4.0 treats difficult buried cable placement in rock conditions using five parameters: 1) Distribution Distance Multiplier, Difficult Terrain; 2) Surface Texture Multiplier; 3) Rock Depth Threshold, inches; 4) Hard Rock Placement Multiplier; and 5) Soft Rock Placement Multiplier. The last three of these pertain to the effect of bedrock close to the surface – see Section 2.7.2 through 2.7.5. The first pertains to difficult soil conditions such as the presence of boulders.

While the typical response to difficult soil conditions is often to simply route cable around those conditions, which could be reflected in this parameter, HM 4.0 instead treats the effect of difficult soil conditions as a multiplier of placement cost - see Parameter 6.5, Surface Texture Multiplier. Therefore, the distribution distance multiplier is set to 1.0.

2.7.2. Rock Depth Threshold, Inches

Definition: The depth of bedrock, less than which (that is, closer to the surface) additional costs are incurred for placing distribution or feeder cable. The depth of bedrock is provided by USGS data for each CBG.

Default Value:

Rock Depth Threshold, inches
24 inches

Support: Cable is normally placed at a minimum depth of 24 inches. Where USGS data indicates the presence of rock closer to the surface, HM 4.0 imposes additional costs.

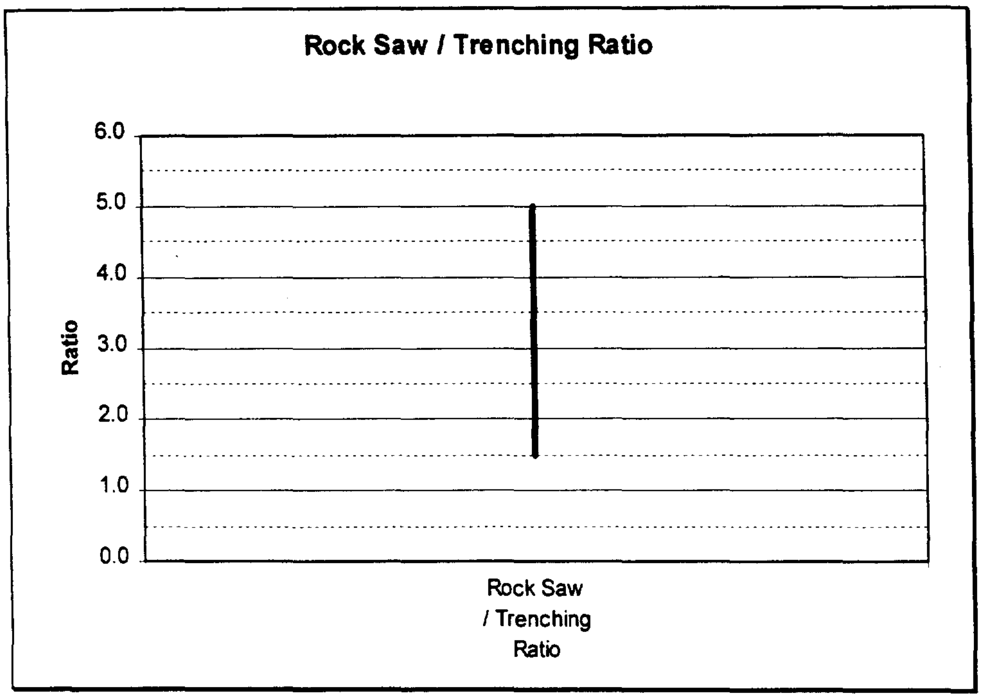
2.7.3. Hard Rock Placement Multiplier

Definition: The increased cost required to place distribution or feeder cable in bedrock classified as hard, when it is within the rock depth threshold of the surface, expressed as a multiplier of normal installation cost per foot.

Default Value:

Hard Rock Placement Multiplier
3.5

Support: A rock saw is used whenever hard rock must be excavated. Information received from independent contractors who perform this type of work is reflected below. Hard rock costs are reflected at the top of the scale.



2.7.4. Soft Rock Placement Multiplier

Definition: The increased cost required to place distribution or feeder cable in bedrock classified as soft, when it is within the rock depth threshold of the surface, expressed as a multiplier of normal installation cost per foot.

Default Value:

Soft Rock Placement Multiplier
2.0

Support: A rock saw or tractor-mounted ripper is used whenever soft rock must be excavated. Information received from independent contractors who perform this type of work is reflected in the figure in section 2.7.3. Soft rock costs are reflected at the lower end of the scale.

2.7.5. Sidewalk / Street Fraction

Definition: The fraction of small, urban CBGs that are streets and sidewalks, used in the comparison of occupied CBG area with number of lines to identify cases where high rise buildings are present. To qualify as a small urban CBG, the total land area must be less than .03 square miles and the line density must exceed 30,000 lines per square mile.

Default Value:

Sidewalk / Street Fraction
.20

Support: The sidewalk/street fraction is computed using a .03 square mile (836,352 square feet) CBG, the largest CBG to which it applies. This densely urban CBG is assumed to be square, which means each side of the CBG is approximately 915 feet long. As a result, the roads and sidewalks running around the outside of such a CBG would cover a total land area of approximately 165,000 square feet (915 feet per side times 4 sides times (15 foot wide sidewalk + .5 times 60 foot wide street), or 20 percent of the CBG's total area. The remaining 80 percent, or non-sidewalk/street land area, is occupied by buildings.

2.7.6. Local RT (per Cluster) Thresholds – Maximum Total Distance

Definition: The maximum potential distribution length, in feet, above which Remote Terminals are located at the center of each cluster, rather than at the center of the CBG, in order to reduce the remaining distribution length.

Default Value:

Local RT (per cluster) Thresholds Maximum Total Distance
18,000 ft.

Support: The default value was chosen to be consistent with the minimum distance at which long loop treatment is usually required.[13]

2.7.7. Town Factor

Definition: The fraction of business and residential customers that are assumed to be located in clusters, as opposed to surrounding areas, for those rural population cases in which the model determines that such clustering is likely. The rural clustering assumption is made for all CBGs falling in the lowest three line density zones, and all other CBGs whose fraction of empty area is greater than 50 percent. The default value is equal to one minus the fraction of rural population that is located on farms, averaged across the U.S.

Default Value:

Town Factor
.85

Support: Derived from data in the *Statistical Abstract of the United States, 1995*. Using rural population (table 44), farm data (table 1105), and 4 pops per farm, town factors are computed as one minus the fraction of rural population that is located on farms (i.e., town factor (state) = 1 – (number of farms * 4 pops per farm) / rural pops). A table containing the computed town factor for each state is provided below.

State	Rural Pop (1,000)[14]	Farms[15] (1,000)	Farm Pop	Town Factor

[13] *BOC Notes on the LEC Networks - 1994*, Bellcore, p. 12-4.

State	Rural Pop (1,000)[14]	Farms[15] (1,000)	Farm Pop	Town Factor
Alabama	1,601	47	188,000	0.8826
Alaska	179	1	4,000	0.9776
Arizona	458	8	32,000	0.9302
Arkansas	1,093	47	188,000	0.8279
California	2,189	85	340,000	0.8447
Colorado	579	27	108,000	0.8134
Connecticut	686	4	16,000	0.9767
Delaware	180	3	12,000	0.9332
Florida	1,971	41	164,000	0.9168
Georgia	2,381	48	192,000	0.9194
Hawaii	122	5	20,000	0.8361
Idaho	429	22	88,000	0.7946
Illinois	1,762	83	332,000	0.8116
Indiana	1,946	68	272,000	0.8602
Iowa	1,094	104	416,000	0.6196
Kansas	765	69	276,000	0.6392
Kentucky	1,775	93	372,000	0.7904
Louisiana	1,348	32	128,000	0.9051
Maine	680	7	28,000	0.9588
Maryland	893	15	60,000	0.9328
Massachusetts	947	7	28,000	0.9704
Michigan	2,739	54	216,000	0.9212
Minnesota	1,319	89	356,000	0.7300
Mississippi	1,362	40	160,000	0.8826
Missouri	1,601	108	432,000	0.7302
Montana	379	25	100,000	0.7363
Nebraska	534	57	228,000	0.5734
Nevada	140	3	12,000	0.9145
New Hampshire	544	3	12,000	0.9779
New Jersey	820	8	32,000	0.9610
New Mexico	409	14	56,000	0.8632
New York	2,826	39	156,000	0.9448
North Carolina	3,291	62	248,000	0.9246
North Dakota	298	34	136,000	0.5443
Ohio	2,808	84	336,000	0.8803
Oklahoma	1,015	70	280,000	0.7243
Oregon	839	37	148,000	0.8236
Pennsylvania	3,693	53	212,000	0.9426
Rhode Island	140	1	4,000	0.9714
South Carolina	1,581	25	100,000	0.9368
South Dakota	348	35	140,000	0.5978
Tennessee	1,907	89	356,000	0.8133
Texas	3,352	186	744,000	0.7780
Utah	224	13	52,000	0.7676
Vermont	382	7	28,000	0.9266

[14] Rural population counts are from the Statistical Abstract, 1995, table 44. For the definition of rural population, see the Statistical Abstract, p.4.

[15] Farm counts from Statistical Abstract, 1995, table 1105 (4 pops/farm). Farms are defined as any place from which $1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the census year.

State	Rural Pop (1,000)[14]	Farms[15] (1,000)	Farm Pop	Town Factor
Virginia	1,894	46	184,000	0.9028
Washington	1,149	37	148,000	0.8712
West Virginia	1,145	21	84,000	0.9267
Wisconsin	1,680	80	320,000	0.8095
Wyoming	159	9	36,000	0.7735

2.7.8. Maximum Lot Size, Acres

Definition: The maximum effective lot size allowed in a non-rural CBG, above which it is assumed that the population is clustered into areas whose effective lot size is the default value (that is, there is a cap on the amount of land each subscriber occupies).

Default Value:

Maximum Lot Size
3.0 acres

Support: Based on observations that subdivisions, towns, or other areas where a grid distribution structure is used rarely consist of plots greater than 3 acres.

2.7.9. Town Lot Size, Acres

Definition: The assumed lot size– including common areas such as streets and parks -- of subscribers residing in rural population clusters.

Default Value:

Town Lot Size
3.0 acres

Support: For clustering in rural areas the model calculates total cluster area as the sum of individual lot sizes. Larger lot sizes thus produce more distribution cable in this case. Assuming three acre lot sizes within a cluster yields a conservatively high cost estimate.